

**DRAFT
GROUNDWATER INFORMATION SHEET**

Arsenic

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The purpose of this groundwater information sheet is to provide general information regarding a specific constituent of concern (COC). The following information is pulled from a variety of sources and data relates mainly to drinking water. For additional information, the reader is encouraged to consult the references cited at the end of the information sheet.

GENERAL INFORMATION	
Constituent of Concern	Arsenic (As)
Aliases	“Arsenic Black”, “Colloidal Arsenic”, “Grey Arsenic” (numerous additional aliases exist for the compound forms of arsenic)
Chemical Formula	As Arsenic exists in oxidation states of -3, 0, 3 (arsenite), and 5 (arsenate). It is widely distributed throughout the earth's crust, most often as arsenic sulfide or as metal arsenates and arsenides.
CAS No.	7440-38-2
Storet No.	01002
Summary	The California Department of Health Services (DHS) regulates Arsenic as a drinking water contaminant. The current State Maximum Contaminant Level (MCL) for arsenic, set by DHS, is 50 µg/L. However, in 2006, the Federal MCL (10 µg/L), will become enforceable unless DHS adopts a new California MCL. Based on DHS data through 2000, 1038 of approximately 16,000 public drinking water wells (active and standby status) have had concentrations of arsenic ≥ 10 µg/L, with most detections occurring in Los Angeles, San Bernardino, and Kern Counties.

REGULATORY AND WATER QUALITY LEVELS¹		
Type	Agency	Concentration
Federal MCL	US EPA, Region 9	10 µg/L
State MCL	DHS	50 µg/L (compliance with Federal MCL of 10 µg/L required in 2006)
Detection Limit for Purposes of Reporting (DLR)	DHS	2 µg/L
Others: CA Prop. 65 Sources of Drinking Water Cancer Potency Factor (1/10 ⁶ cancer risk) IRIS Reference Dose (noncancer health effect)	OEHHA OEHHA US EPA, Region 9	5 µg/L 0.023 µg/L 2.1 µg/L

¹These levels generally relate to drinking water, other water quality levels may exist. For further information, see A Compilation of Water Quality Goals (Marshack, 2000).

Important Regulatory Dates:

July 1, 2002 – Starting on this date, public water supply systems that detect between 5 and 10 µg/L arsenic must include an educational statement in their yearly Consumer Confidence Reports (CCRs) and systems that detect between 10 and 50 µg/L arsenic must include specific health effects information in their yearly CCRs

December 31, 2002 – A California Public Health Goal (PHG) for drinking water must be established by OEHHA.

June 30, 2004 –California DHS must adopt a revised state MCL that is at least as stringent as the federal MCL.

January 23, 2006 – The federal MCL of 10 µg/L becomes enforceable unless DHS adopts a California MCL.

December 31, 2007 – All groundwater drinking water sources must have completed initial monitoring.

SUMMARY OF DETECTIONS IN PUBLIC DRINKING WATER WELLS²	
Detection Type	Number of Groundwater Sources
Number of active and standby public drinking water wells ³ with arsenic concentration ≥ 10µg/L.	1038 of approximately 16,000
Top 3 Counties having public drinking water wells ³ with arsenic concentration ≥ 10 µg/L.	Kern, San Bernardino, Los Angeles
Top 3 Regions having public drinking water wells ³ with arsenic concentration ≥ 10 µg/L.	Central Valley, Central Coast, Lahontan

²Based on DHS data collected from 1984-2001 (Geotracker). See Figure 1.

³In general, drinking water from active and standby wells is treated or blended so consumers are not exposed to water exceeding MCLs. Individual wells and wells for small water systems not regulated by DHS are not

included in these figures.

ANALYTICAL INFORMATION	
Analytical Test Method	US EPA Methods: 200.7 (ICP), 200.8 (ICP/MS), and 200.9 (AA - Platform) ASTM Methods: D-2972-93C (AA – Furnace) and D-2972-93B (Hydride AA) APHA Standard Methods: 3120B (ICP), 3113B (AA – Furnace), 3114B (Hydride AA)
Detection Limit	Most methods can attain the 2 µg/L DLR. An emerging method, Hydride ICP-MS (EPA method 1632, IC-ICP-MS), is able to achieve sub-µg/L detection limits and speciate the arsenic components present in samples.
Known Limitations to Analytical Methods	Few laboratories are equipped to conduct ICP-MS analysis, necessary for low detection limit quantification and speciation. Sample handling and preservation methods differ for different analytical methods. No single method is appropriate for all sample matrices, but preservation is very important due to speciation concerns. Sulfide interference may occur in field testing methods (colorimetric). Sample filtration may be done but is not required.
Public Drinking Water Testing Requirements	Arsenic is a regulated chemical for drinking water sources, with monitoring and compliance requirements (Title 22, Section 64431, et seq.).

ARSENIC OCCURRENCE	
Anthropogenic Sources	<p>Arsenic-containing chemicals or materials are used in the anthropogenic processes discussed below. These chemicals or materials can be released into the environment through improper handling or disposal practices. Almost all of the arsenic used is obtained as a by-product of smelting of ores of copper, lead, cobalt and gold. Mining of these commodities and the management of waste materials associated with mining operations is a significant source of arsenic released to the environment.</p> <p>Commercial and industrial uses:</p> <ul style="list-style-type: none"> - alloying agents in the manufacture of transistors, lasers, semiconductors, and solar cells. - processing of glass, ceramics, paints, pigments, dyes and soaps, textiles, paper, metal adhesives, wood preservatives, catalysts, pyrotechnics, and ammunition.

	<p>Agricultural uses:</p> <ul style="list-style-type: none"> - Pesticides, insecticides, disease prevention, cattle and sheep dips, algacides. - hide tanning. - debarking trees, soil sterilant, and livestock feed additives. <p>Medicinal uses:</p> <ul style="list-style-type: none"> - Antisyphilitic drugs, treatment of other diseases.
Natural Sources	<p>Arsenic is a metalloid element, meaning it has physiochemical properties of both metals and nonmetals. Arsenic is ubiquitous in the environment and is naturally present in soil, water, air, plants and animals. Naturally occurring arsenic can be found in a variety of solid phases, including a component of volcanic glass in volcanic rocks, adsorbed to and co-precipitated with metal oxides (especially iron oxides), adsorbed to clay-mineral surfaces, and associated with sulfide minerals and organic carbon.</p> <p>The average concentration of arsenic in the earth's crust has been estimated to be 2 parts per million (ppm). The concentrations of arsenic in soil (0.1 to 40 ppm) and sedimentary rocks (13 ppm) are generally higher than the average in the earth's crust due to movement and accumulation of the arsenic through weathering processes. Weathering of arsenic-containing rocks is considered to be the primary natural source of arsenic in the environment. Additionally, volcanic activity and forest fires can release arsenic into the atmosphere where it later falls to earth; however, precipitation in unpolluted areas usually contains less than 1 ppb arsenic.</p>
History of Occurrence	<p>Arsenic is found in groundwater throughout the state, resulting from its natural occurrence. It may also be present in localized environments in high concentrations as a result of specific releases, such as from mine tailings and chemical spills.</p>
Contaminant Transport Characteristics	<p>In water, the most common valence states of arsenic are As(V), or arsenate, which is more prevalent in well-oxygenated (aerobic) surface waters, and As(III), or arsenite, which is more likely to occur in anaerobic groundwater or deep lake sediments (reducing environments). The concentration of dissolved arsenic can be very dependent on the pH of the water. Arsenite is more mobile, toxic, and difficult to remove from drinking-water supplies than arsenate, although both arsenite and arsenate are included in drinking water standards and other water quality levels for arsenic.</p> <p>Arsenic mobility in groundwater is dependent on the physical</p>

	<p>and chemical properties of the aquifer, although two types of processes generally control its movement: adsorption/desorption reactions and precipitation/dissolution reactions. During adsorption reactions, dissolved arsenic adheres to the surface of solid aquifer materials. Desorption removes the arsenic from aquifer materials and releases it into the surrounding groundwater. Additionally, arsenic-containing aquifer materials can dissolve as groundwater moves through the aquifer, releasing arsenic to groundwater. The rate of arsenic movement in groundwater can vary considerably, depending on the hydraulic gradient, as well as aquifer chemistry.</p>
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REMEDIATION & TREATMENT TECHNOLOGIES

Arsenic treatment tends to be expensive, not just because of the more exotic treatment technologies required, but because of the large volumes of groundwater that typically must be treated when the source of the arsenic is naturally occurring as opposed to a “point source”. The main types of treatment processes used are:

- Precipitative processes, including coagulation/filtration (C/F), direct filtration, coagulation assisted microfiltration, enhanced coagulation, lime softening (LS), and enhanced lime softening;
- Adsorption processes, specifically activated alumina (AA);
- Ion exchange (IX) processes, specifically anion exchange;
- Membrane filtration, including reverse osmosis (RO), and electrodialysis reversal (EDR);
- Granular ferric hydroxide is being investigated, and may be an effective technology for removing arsenic

When the affected water systems have fewer than 500 service connections, the US EPA does not consider the precipitative and membrane filtration processes listed above as Best Available Technologies (BATs).

There are also concerns about the high relative cost for disposal of treatment wastes from arsenic removal.

HEALTH EFFECT INFORMATION

When groundwater is the transport and exposure medium, we are primarily concerned with ingestion of contaminated water as the route for greatest human exposure to arsenic. In humans, arsenic is quickly absorbed after ingestion, while dermal exposure to arsenic only results in a small amount of arsenic entering the body. Upon absorption from the gastrointestinal tract, the liver changes some of the arsenic to a less harmful organic form. Both inorganic and organic forms are excreted from the body in urine. Most of the arsenic will be excreted within several days, although some will remain in the body for several months or longer.

Inorganic arsenic has been recognized as a human poison since ancient times, with large oral doses (above 60,000 ppb in food or water) producing death. However, there is some evidence that the small amounts of arsenic in the normal diet (10–50 ppb) may be beneficial to human health. Ingestion of moderate to elevated levels inorganic arsenic (greater than 300 ppb) may cause irritation of the stomach and intestines, with symptoms such as pain, nausea, vomiting, and diarrhea. Other effects from the ingestion of arsenic include decreased production of red and white blood cells, abnormal heart rhythm, blood-vessel damage, and impaired nerve function causing a "pins and needles" sensation in the hands and feet. Although there is no strong evidence that arsenic can injure pregnant women or their fetuses, studies in animals show that doses of arsenic that are large enough to cause illness in pregnant females may cause low birth weight, fetal malformations, or even fetal death.

Arsenic is a known human carcinogen, and ingestion of arsenic has been reported to increase the risk of cancer in the liver, bladder, kidney, lung and skin. Arsenic is known to the State of California to cause cancer, for purposes of the Safe Drinking Water and Toxic Enforcement Act of 1986 ("Proposition 65"). It was added to the list of carcinogens in 1987.

Long-term oral exposure to inorganic arsenic may cause patterns of skin changes, including a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. A small number of the corns may ultimately develop into skin cancer.

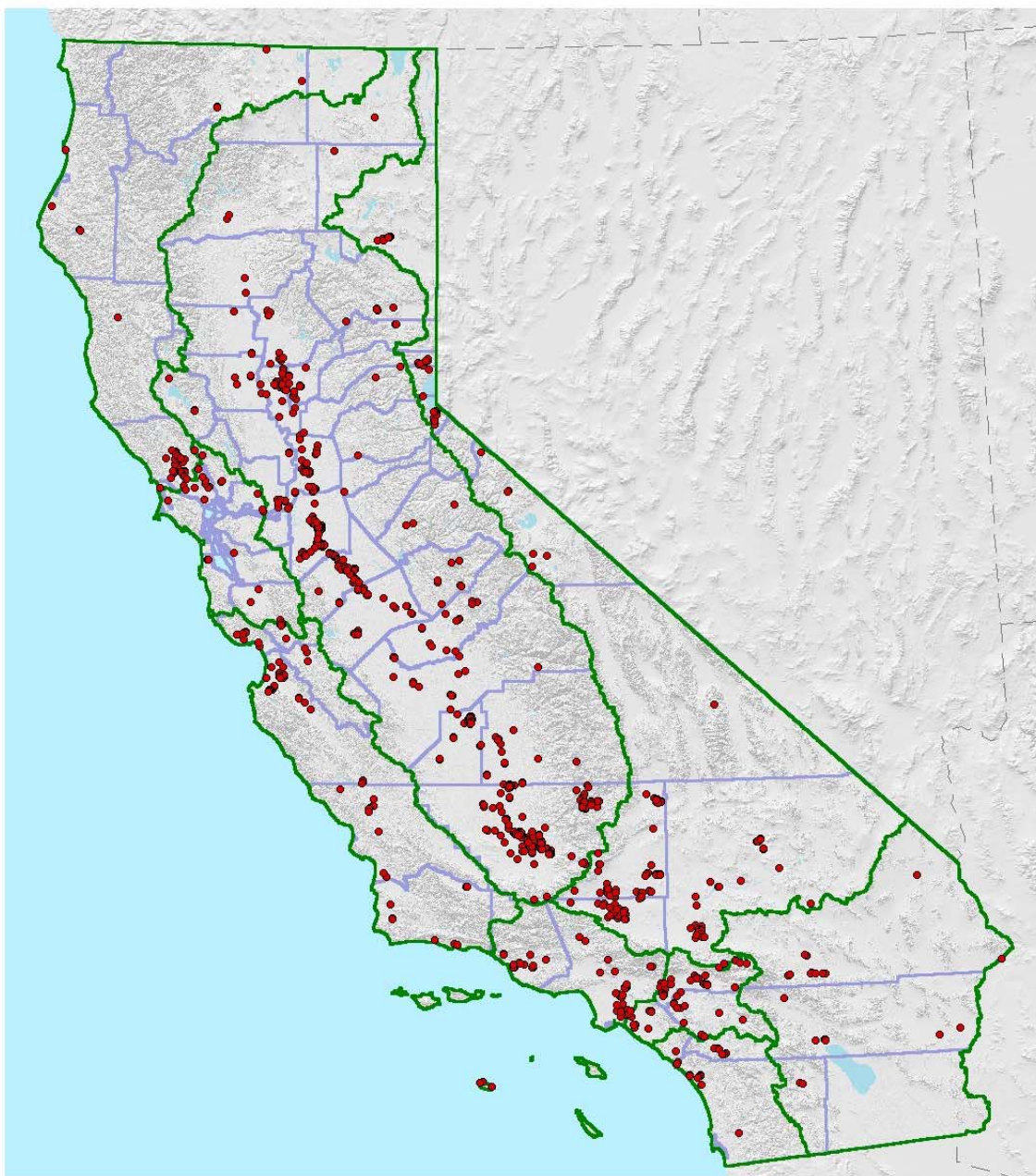
In September 2001, the National Academy of Sciences estimated that the lifetime risk of developing bladder or lung cancer from arsenic in tap water, assuming 2 liters consumption per day, is greater than 3 in 1,000 for an arsenic level of 10 ppb. For most chemicals, the highest cancer risk US EPA and DHS usually allow in tap water is 1 in 10,000.

KEY REFERENCES

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11. United Nations. Water and Sanitation. *United Nations Synthesis Report on Arsenic in Drinking Water*. http://www.who.int/water_sanitation_health/Arsenic/ArsenicUNReptoc.htm (Oct. 23, 2002)
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FOR MORE INFORMATION, CONTACT:
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Groundwater Information Sheet: Arsenic
Figure 1



**Active and Standby DHS Wells (1,038 Total) with at Least
One Detection of Arsenic \geq 10 PPB New Federal MCL**

Source: 1984 - 2000 DHS Data (Map Revised 10/02/02)

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GEOTRACKER